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INVESTIGATING THE POSSIBILITY OF OBTAINING STELLITE POWDER

V. G. Teplenko, Z. V. Solov'yeva,
G. T. Makshantseva

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V. G. Teplenko, Z. V. Solov'yeva
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ABSTRACT. 1. The basic technological parameters for obtaining stellite powder by the method of combined reduction have been established.

To improve the workability of the sintered mass a "separator"--sodium chloride in the amount of 3-5 percent of the alloy mass is introduced into the charge.

2. The stellite powder has good pressing properties. Briquettes made of it by the method of hot pressing have a relative density which is close to the theoretical value 91-93 percent; their hardness is 43-44 HRC, i.e., it is of the same order as that of cast stellite with the same composition.

The high resistance to air and thermal stability as well as stability /115* against corrosion, erosion and oxidation at high temperatures determine the effectiveness of applying stellite parts or parts with stellite (fused) coatings. However in view of the excessive hardness which is produced by the eutectic, consisting of a solid solution and of chromium carbides (refs. 1, 2, 3) stellites cannot be machined which limits the range of their application.

In some cases, for example in the fabrication of gas turbines, dies and other devices the method of precision casting is used with a dispensable pattern. However this method leads to large waste factors for metals particularly for the expensive and scarce cobalt which is the basis of stellites. For this reason we investigated the possibility of producing stellite parts by the method of powder metallurgy.

The method of combined reduction of oxides by calcium hydride was used to obtain stellite powder containing 0.91 percent C; 2.2 percent Si; 27.5 percent Cr; 4.2 percent W; 61.8 percent Co; 3.3 percent Fe[1].

The following were introduced into the charge for reducing tungsten and iron: oxides in the form of chromium oxide and metallic chromium, carbon in the form of lamp black or in the form of ground wood charcoal, and silicon

[1] The stellite of this composition is forgable and viscous; its hardness lies in the range for 40 to 45 HRC (ref. 1).

* Numbers in the margin indicate original pagination in the foreign text.

and cobalt in the form of metallic powders.

The introduction of cobalt oxide or peroxide into the charge is not expedient due to the high thermal effect of the reaction.

When cobalt oxide-peroxide is reduced by calcium hydride more than 302 kilo Joules (72 kilocalories) of heat are liberated per one gram-atom of the resulting metal.

A carefully prepared charge consisting of metal oxides, metallic powders, lamp black and calcium hydride (computed for the total reduction of oxides with an excess of 20 percent), was placed into a stainless steel converter. The charge was heated to a temperature of 1100-1150° and was soaked at this temperature for a period of 4-5 hours (the melting temperature for stellite of this composition is 1200-1300°C (refs. 2 and 4)).

The resulting sintered mass was crushed under a press and ground until the particle size was 0.2mm. It was then "quenched" with water. The pulp was treated with weak hydrochloric acid (pH=3), and the resulting stellite powder was washed with water and alcohol and dried at a temperature of 40-50°C in vacuum.

During the reduction process of the charge which contained carbon black, charge losses were observed in the temperature range from 400 to 800° due to the intense breakdown of the calcium hydride accompanied by a violent liberation of hydrogen.

The reduction reaction took place smoothly when chromium oxide was replaced /116 with metallic chromium powder and then there was a corresponding decrease in the amount of calcium hydride from 60 to 10 percent of the alloy by weight. However the sintered mass was difficult to process and therefore it was necessary to introduce a special "separator" into the charge. This separator consisted of sodium chloride in the amount of 40-50 percent of the alloy by weight. In this case the reduction process took place smoothly, and the alloy powder contained the specified amount of carbon. However in view of the large amount of "separator" introduced into the charge the content of ferromagnetic particles in the powder reached 50 percent by weight. This shows that the homogeneity of the obtained powder is inadequate. Table 1 shows the content of ferromagnetic particles in the stellite powder as a function of the quantity of "separator" in the charge and of the reduction process. We can see from table 1 that the introduction of a substantial quantity of sodium chloride into the charge impedes the process of alloy formation. The optimum quantity of the "separator" (sodium chloride) is 3 to 5 percent of the alloy weight. The optimum soaking time at a temperature of 1100-1150°C is 4 hours.

The best results in producing stellite powder with a carbon contact within narrow specified limits were obtained when chromium carbide Cr_3C_2 containing 13.3 percent carbon by weight was introduced into the charge in place of carbon black.

TABLE 1. THE CONTENT OF FERROMAGNETIC PARTICLES IN STELLITE POWDER AS A FUNCTION OF THE AMOUNT OF "SEPARATOR" IN THE CHARGE AND OF THE REDUCTION PROCESS.

1		2		3
NaCl	CaO	4	5	
—	60	1100	3	3,4*
—	60	1100	4	0,6*
50	10	1150	2	54
50	10	1150	4	47
50	10	1150	5	41
15	10	1150	4	32
10	10	1150	4	30
5	10	1150	4	10
5	10	1100	4	5—10
3	10	1100	4	6

*In the first two experiments chromium oxide was introduced into the charge while in the remaining experiments metallic chromium powder was introduced.

1. the amount of "separator" in percent of alloy weight; 2. reduction process; 3. the amount of ferromagnetic particles in percent; 4. temperature: degrees C; 5. soaking time in hours.

Chromium carbide was obtained by the direct interaction of metallic chromium powder and carbon black at a temperature of 1100-1200°C (ref. 5).

On the basis of the investigations which have been carried out the following basic technological parameters for obtaining stellite powders have been established.

1. The initial materials and composition of the charge are presented in table 2.
2. The reduction temperature is 1100-1150°C.
3. The soaking time at this temperature is 4 hours. The output of useful powder was 90-92 percent.

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TABLE 2. THE COMPOSITION OF THE CHARGE FOR 1 KILOGRAM OF STELLITE, IN KILOGRAMS.

metallic powder			oxides		Cr_3C_2	CaH_2	NaCl
Co	Cr	Si	WO_3	Fe_2O_3			
0,680	0,165	0,024	0,059	0,036	0,096	0,0182	0,033

The resulting alloy powder satisfies the technical specifications and has the following composition, in percent:

	C	Si	Cr	W
According to technical specifications	0.91±0.2	2.2±0.2	27.5±0.5	4.2±0.2
Actually obtained	0.89-0.91	2.0-2.3	27.0 -27.6	4.0-4.2

	Co	Fe	P	S	Mn
According to technical specifications	61.8±0.5	3.3±0.2	<0.01	<0.008	<0.24
Actually obtained	61.7-62.0	3.2-3.4	<0.01	<0.008	<0.24

The X-ray analyses of the obtained powder reveal the presence of a solid solution based on cobalt and the carbide phase (chromium carbide and complex carbides).

The average granulometric composition of the stellite powder is presented below:

Particle size in mm	Greater than 0.2	0.2-0.16	0.16-0.10
Fraction content in percent	Not present	19	7
Particle size in mm	0.10-0.063	0.063-0.05	Less than 0.05
Fraction content in percent	31	10	33

The powder particles consisted of porous granules with an extensively branched rough surface (the average value of the poured mass is 2.0 grams/cm^3).

When the compressed briquettes were sintered at a temperature of 1280-1300°C in vacuum and in hydrogen atmosphere their shrinkage was not observed. In this connection the stellite powder sintering was carried out under pressure (hot pressing). It is known that sintering under pressure produces a more effective contact of powder particles in view of the increase in its plasticity during heating (ref. 6).

Table 3 presents the processes for the hot pressing of stellite powder and the properties of the briquettes which were obtained.

It follows from table 3 that the density and hardness of sintered briquettes are close in their values to those characteristic of cast stellite*; the residual porosity does not exceed 9 percent.

When the test temperature was raised to 600°C the hardness of the cermet stellite was reduced to 41 HRC, i.e., by less than 5 percent. Cast stellites of the same composition are characterized by a slower drop in hardness as the

*The density of stellite obtained by smelting the powder is 8.29 grams/cm^3.

temperature is increased.

TABLE 3. PROCESSES FOR THE HOT PRESSING OF STELLITE POWDER AND THE PROPERTIES OF BRIQUETTES.

1		4	5					10		HRC
2	3		6	7	8		9	g/cm³	%	
					mN/m²	kg/cm²				
30	20	116	1360	(11)	16,7	170	12	7,72	93,3	43,4
30	20	117	1220	5	13,7	140	22	8,01	97,0	43,3
30	20	116	1240	5	13,7	140	18	7,73	93,4	44,1
30	20	126	1220	5	13,7	140	18	7,58	91,5	44,3
30	20	117	1340	(11)	16,7	170	18	7,51	90,6	43,0
30	20	117	1250	(11)	19,6	200	18	7,57	91,4	43,0

1. dimension of the briquettes in millimeters; 2. diameter; 3. height; 4. mass in grams; 5. hot pressing process; 6. temperature in degrees C; 7. soaking time in minutes; 8. maximum load; 9. pressing time in minutes; 10. density; 11. without soaking.

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